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Description of a new species and a redescription of *Cirrodrilus aomorensis* (Yamaguchi, 1934) with a detailed distribution of the branchiobdellidans (Annelida: Clitellata) in northern Honshu, Japan

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Abstract.—*Cirrodrilus tsugarensis*, a new species, is described and *C. aomorensis* is redescribed from their crayfish host, *Cambaroides japonicus*. A detailed survey of the crayfish and their branchiobdellidans was conducted in Aomori and adjacent Prefectures in northern Honshu, Japan. *Cirrodrilus tsugarensis* was only found in one isolated locality on the Tsugaru Peninsula in Aomori Prefecture, while *C. aomorensis* has an extensive distribution throughout the Prefecture. This survey also confirmed one site containing two introduced species, *Cirrodrilus inukaii* and *C. uchidai*, from Hokkaido.

East Asian branchiobdellidans have been reported as symbionts on freshwater crayfishes and other crustaceans in an area that includes China, southeastern Russia, the Korean peninsula, and Japan (Yamaguchi 1934, Gelder 1987, Timm 1991). Timm (1991:329) divided these branchiobdellidans into two groups—"mainland" and "island" or Japanese. Japan has a high degree of endemism in both the twelve reported species of branchiobdellidans (Pierantoni 1906, 1912; Yamaguchi 1932a, 1932b, 1932c, 1933, 1934) on its only native species of crayfish, *Cambaroides japonicus* (de Haan, 1841). The distribution of *C. japonicus* is restricted to Hokkaido and the northern portion of Honshu Islands. In the latter area, Aomori Prefecture, only one species of branchiobdellidan has been recorded, *Cirrodrilus aomorensis* Yamaguchi, 1934.

Branchiobdella digitata Pierantoni, 1906, is the only reported Japanese branchiobdellidan not belonging to the genus *Cirrodrilus* Pierantoni, 1905. Pierantoni (1906, 1912) named a number of new species and assigned them to a new genus, *Stephanodrilus*. Professor H. Yamaguchi and others accepted this status until Holt (1967) showed *Stephanodrilus* to be a junior synonym of *Cirrodrilus*. Yamaguchi (1934: 196) first questioned the validity of *B. digitata* and later Timm (1991:328) assigned the species to the status of incertae sedis, although this status was not included in the world checklist of branchiobdellidans (Gelder 1996a).

The monograph by Yamaguchi (1934) provided the first comprehensive account of East Asian branchiobdellidans. Although a significant resource, its potential value has not been realized because a number of important facts were ommitted, including: designation of type specimens, deposition of type specimens in an academic institution for inclusion in their collection's catalogue, description of the exact location where types were collected, and complete type descriptions with independent text and illustrated description of each new species.

When Yamaguchi's preserved specimens, slide collection, and laboratory and field notes appeared to be lost after his death, it seemed unlikely that these omissions could ever be rectified. When Dr. A. Ohtaka rediscovered Prof. H. Yamaguchi's branchiobdellidan slide collection in the care of Dr. Yukiyoshi Kamihira, Hakodate University, Hokkaido, Japan, in 1996, there was hope that the omissions listed above could be redressed from the original specimens and written records. However, this proved impossible as none of the slides had any specimen names on them and the laboratory and field books were not to be found.

As part of a comprehensive review of branchiobdellidans and their crayfish hosts in Japan, the distribution of the native Japanese crayfish, *C. japonicus*, in northern Honshu was studied by Dr. A. Ohtaka and his Japanese colleagues from 1994 to 1999. During this study they found several branchiobdellidan species on the crayfish compared to the single species reported by Yamaguchi (1934). This paper contains a description of a new species, a redescription of *C. aomorensis*, and the distribution of branchiobdellidans and their hosts found on northern Honshu.

It is usual in Japan to give organisms a common as well as a latinized, Linnean name. This pragmatic system of common names is often used to the exclusion of the Linnean names (Grygier 1993). In recognition of this system and to prevent possible future ambiguity, the Japanese common names are given following the Linnean name in formal descriptions. This will also make it easier to incorporate the taxonomic and distributional information in this paper into the National Survey of Japanese Endemic Species.

Materials and Methods

Unless otherwise stated, branchiobdellidans were removed from *C. japonicus*, fixed in 10% formalin or AFA (Humason 1979) solutions, dehydrated in a graded series of ethanol and water solutions, cleared in methyl salicylate, and mounted in Canada balsam for examination. The anatomical terminology used in this paper follows that proposed by Gelder (1996b). The term "terete" is used to describe the cylindrical body tapering towards the head and posterior attachment disc, respectively. "Pyriform" refers to a structure that is pear-shape. Because peristomial appendages are a prime character in the identification of species, particularly in the genus *Cirrodrilus*, a clear definition of the terms "tentacles" and "lobes" is needed. A "tentacle" is an appendage that is as long or longer than wide, while a "lobe" is shorter than it is wide. Some latitude in these terms will always exist due to the contraction or extension of the appendages due to artifacts of fixation. Specimens from the type series of the new species have been deposited in the Division of Biological Sciences, Graduate School of Science, Hokkaido University (ZIHU), Japan, and the National Museum of Natural History (USNM), Smithsonian Institution, Washington D.C., U.S.A.

Cirrodrilus tsugarensis, new species (Japanese name: Tsugaru zariganimimizu) Fig. 1

Type specimens.—Holotype, ZIHU-1295, on *Cambaroides japonicus* (de Haan, 1841) removed from a stream at the town of Imabetsu, Tsugaru Peninsula, Aomori Prefecture, Honshu, Japan (41°13′13.0″N, 140°33′36.6″E) by A. Ohtaka on the 9 Sep 1997. Paratypes, ZIHU 1296 and 1297, USNM 186574 were collected from the type location on 14 Nov by A. Ohtaka. Seven specimens from the first type collections were mounted in CMCP-10 and after six months the soft-tissues were damaged beyond recognition.

Diagnosis.—Body terete to pyriform, about 1.2 mm long fixed, dorsal segmental appendages absent; head broader than segment 1 and posterior attachment disc; peristomium short, almost as wide as segment

1, tentacle length similar, dorsal lip five tentacles, lateral tentacles three pairs, ventral lip small, not incised, with one pair of lobes laterally; 16 oral papillae present; jaws triangular, similar shape and size, large median tooth with three pairs small teeth across anterior surface; pharynx with one pair of deep sulci; glandular atrium tubular, convoluted, slightly dilated ental half, length about 2.0 times diameter of segment; muscular atrium tubular, length about 1/2 diameter of segment; ovoid bursa length about 1/4 diameter of segment; spermatheca length about 1.3 times segment diameter, pyriform bulb with ental process absent, duct tubular with ental half dilated.

Etymology.—Epithet given for the Tsugaru Peninsular in western Aomori Prefecture, Honshu, Japan, the type locality for this new species.

Description.—Four fixed specimens averaged 1.26 mm in length and ranged from 1.07–1.36 mm long. The body shape is terete to pyriform with no supernumerary muscles or dorsal segmental appendages (Fig. 1A). The anterior nephridial pores open separately onto the dorso-lateral surface of segment 3. The head slightly broader than segment 1 and posterior attachment disc. The peristomium is shorter than head and nearly as broad as segment 1. There are 11 peristomial tentacles of similar length; five are located on the dorsal lip and three pairs of lateral tentacles. The ventral lip is small, not incised (Fig. 1B, arrowhead), with one small lobe on each side. There are 16 oral papillae. Both jaws are triangular and similar in size with a large median tooth, curved slightly posteriorly, and six small teeth. The median pair of small teeth are located at the base of the large tooth on the anterior margin along with the other two pairs on the lateral crest; dental formula 3-1-3/3-1-3 (Fig. 1C–D). The pharynx has a single deep dorsal and ventral sulcus. A pair of testes is located in segments 5 and 6. The spermatozoa are collected by four sperm funnels. The two funnels in each segment merge into vas efferens that then join to form a vasa deferentia; each vasa deferentia enters the glandular atrium in its median region (Fig. 1E). The remaining male organs are located in segment 6. The glandular atrium is tubular and convoluted, with the ental half slightly dilated. The total length of the atrium is about 2.0 times the diameter of the segment. This is attached to the muscular atrium, which is about 1/2 the length of the segment diameter. The muscular atrium enters the ovoid bursa, whose length is about 1/4 the diameter of the segment, then merges with an unarmed eversible penis located in the ental half of the bursa. The spermatheca is located in segment 5 and consists of a pyriform bulb without an ental process. The bulb opens into the duct through a small internal papilla. The duct is tubular with the ental half slightly dilated (Fig. 1E). The dorsal epidermis of segment 6 has a thick, localized region of gland cells, two times the thickness of the surrounding clitellum.

Variations.—The median tentacle on the dorsal lip may appear shorter than the other tentacles (Fig. 1B, arrowhead). The ental region of the spermathecal duct and the bulb are usually narrow tubes, but both become distended and rounded when filled with sperm, as shown in Fig. 1E.

Distribution.—Restricted to type locality.

Host.—*Cambaroides japonicus* (de Haan, 1841).

Remarks.—Specimens of this species were found on the surface of the carapace, abdomen, and appendages of the host. No other branchiobdellidans have been found in the type locality.

The small, unincised ventral lip (Fig. 1B) is a constant and important character in the *C. tsugarensis*. Since it is possible that the method of fixation has caused this appearance, the character should be used, but treated with caution. The jaws are shown in Fig. 1D with their teeth pointing posteriorly, a position in which they are usually observed except when feeding. The ingested material in the stomach and intestine of the specimens consisted on small clumps of

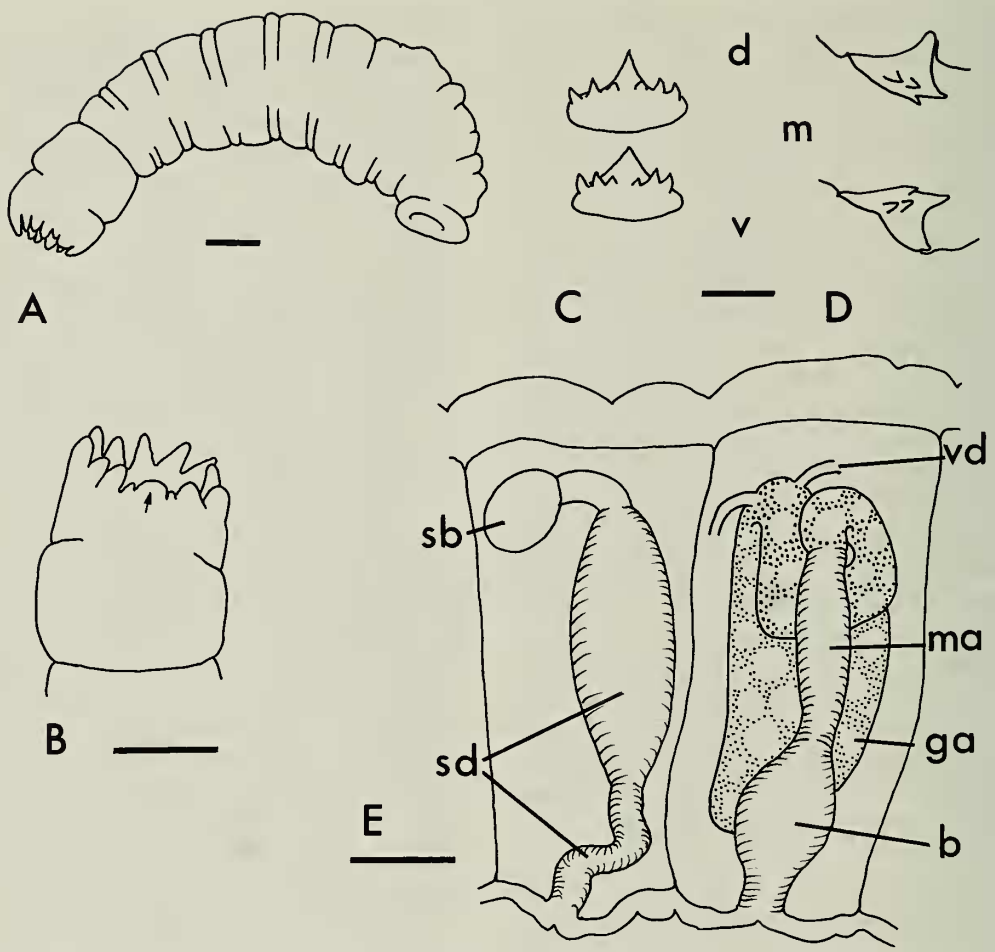

Fig. 1. *Cirrodrilus tsugarensis*: A, Lateral view of holotype, scale bar = 0.1 mm; B, ventral view of the peristomium from a semi-permanent prepared type specimen, scale bar = 0.1 mm; C, jaws of paratype from an anterior aspect, scale bar = 20 μm; D, jaws of holotype from a lateral aspect, scale bar = 20 μm; E, segments 5 and 6 with spermatheca and male genitalia respectively from the holotype drawn from the ventral aspect, scale bar = 50 μm. Abbreviations: b, bursa; d, dorsal jaw; ga, glandular atrium; m, mouth; ma, muscular atrium; sb, spermathecal bulb; sd, spermathecal duct; v, ventral jaw; vd, vas deferens.

"detritus" composed of silt grains and flocculant material. Exoskeletons of arthropod daphnids and the test of a sarcodinid, possibly a cyphoderid, were observed.

Discussion.—The combination of features that defines *C. tsugarensis* from other species of *Cirrodrilus* are the number and size of the peristomial appendages, and the morphology of the jaws. However, the form of each of the features is found in other species. The only other described, native branchiobdellidan on Honshu, *C. aomorensis*, is easily distinguishable from *C. tsugarensis* by the seven tentacles of alternating length on the dorsal lip, only two pairs of lateral tentacles, and a dental formula of 4-1-4/4-1-4 with the dorsal median tooth curving anteriorly.

The five dorsal lip tentacles present in *C. tsugarensis* are also found in *C. makinoi*, which is reported only on Hokkaido. In *C. makinoi*, the median tentacle is always shorter than the other four. This character state has been observed once in the new

species. Although Yamaguchi (1934:202) reported that *C. makinoi* had only two pairs of lateral tentacles and an incised, large ventral lip, his drawings of the lateral and ventral views of the peristomium that show three pairs of lateral tentacles or lobes are taken as being accurate. The presence of eight small teeth in a dental formula of 4-1-4/4-1-4, and three pairs of lateral tentacles, separates *C. makinoi* from the new species.

The peristomial tentacle arrangement of *C. tsugarensis* is unlike that on any of the branchiobdellidan species described from the Asian mainland. The new species has a dental formula of, 3-1-3/3-1-3, and this is the same as the following mainland species: *Cirrodrilus kawamurai* (Yamaguchi, 1934), *Cirrodrilus quaditentacularis* (Liu, 1984), *Hidejiodrilus koreanus* (Pierantoni, 1912), and possibly *Cirrodrilus aequiannulus* (Liu, 1984). Whether this dental arrangement is a plesiomorphic condition or a result of convergence is impossible to say at this point. The only other source of anatomical characters is the male reproductive system, which appears to be consistent throughout the genus based on current descriptions.

Emended Species Description

Cirrodrilus aomorensis (Yamaguchi, 1934)
(Japanese name: Aomori-zariganimimizu)
Fig. 2

References.—Yamaguchi 1934:196, Timm 1991:329, Gelder 1996a.

Type material.—None designated by Yamaguchi.

Material examined.—Ten specimens from Professor Yamaguchi's slide collection, probably from Mekasawa or Shichinohe Towns, Aomori Prefecture (Yamaguchi 1934:196); these slides did not carry any species identification, collection data or catalog markings. Additionally 11 preserved specimens that were collected from the Nitose Stream, Tenmabayashi Village, Aomori Prefecture, on 14 July 1999 were examined. This was supplemented by observations using a Nikon microscope with Normarski Differential Interference Contrast (DIC) illumination on living specimens collected on 24 May 1999 from a branch of the Arakawa River above the Shimoyu Reservoir, Aomori City, Aomori Prefecture. Three specimens from the Tenmabayashi Village collection have been deposited at Hokkaido University museum (ZIHU-1298, 1299, and 1300).

Brief description.—Body terete to club-shaped (Fig. 2A), about 1.3 mm long, dorsal ridges and supernumerary muscles absent, anterior nephridial pores open separately on latero-dorsal surfaces of segment 3, paired lateral epidermal glands on segments 8 and 9; dorsal lip of peristomium with 4 long tentacles alternating with 3 shorter ones, 2 pairs of shorter lateral tentacles, ventral lip with a pair of short lobes laterally and a slight median incision (Fig. 2D); oral papillae 16; jaws dissimilar in size, dorsal larger, large median tooth, 4 pairs of small lateral teeth on anterior margin, ventral jaw smaller with same dentition, dental formula 4-1-4/4-1-4 (Fig. 2B–C); glandular atrium tubular, folded, length about two times diameter of segment, vasa deferentia enter gland three quarters of length from ental end (Fig. 2H); muscular atrium short, spindle-shaped; bursa spherical, penis base sub-conical, narrow, irregularly folded eversible penis entally; spermatheca length is 1.5 times the diameter of segment, sub-spherical bulb entally, a narrow duct, a median spindle-shaped dilation, a prominent papilla separates the median portion and ental chamber.

Variations.—The shape of the body is terete but can appear pyriform if fixation has caused the longitudinal muscles to contract significantly. Similarly, the shape of the peristomial lips and their appendages can vary in proportion to each other in response to fixatives. An optimal view of the peristomium was drawn by Yamaguchi (1934) and was redrawn here (Fig. 2D), however, this condition is rarely found in preserved

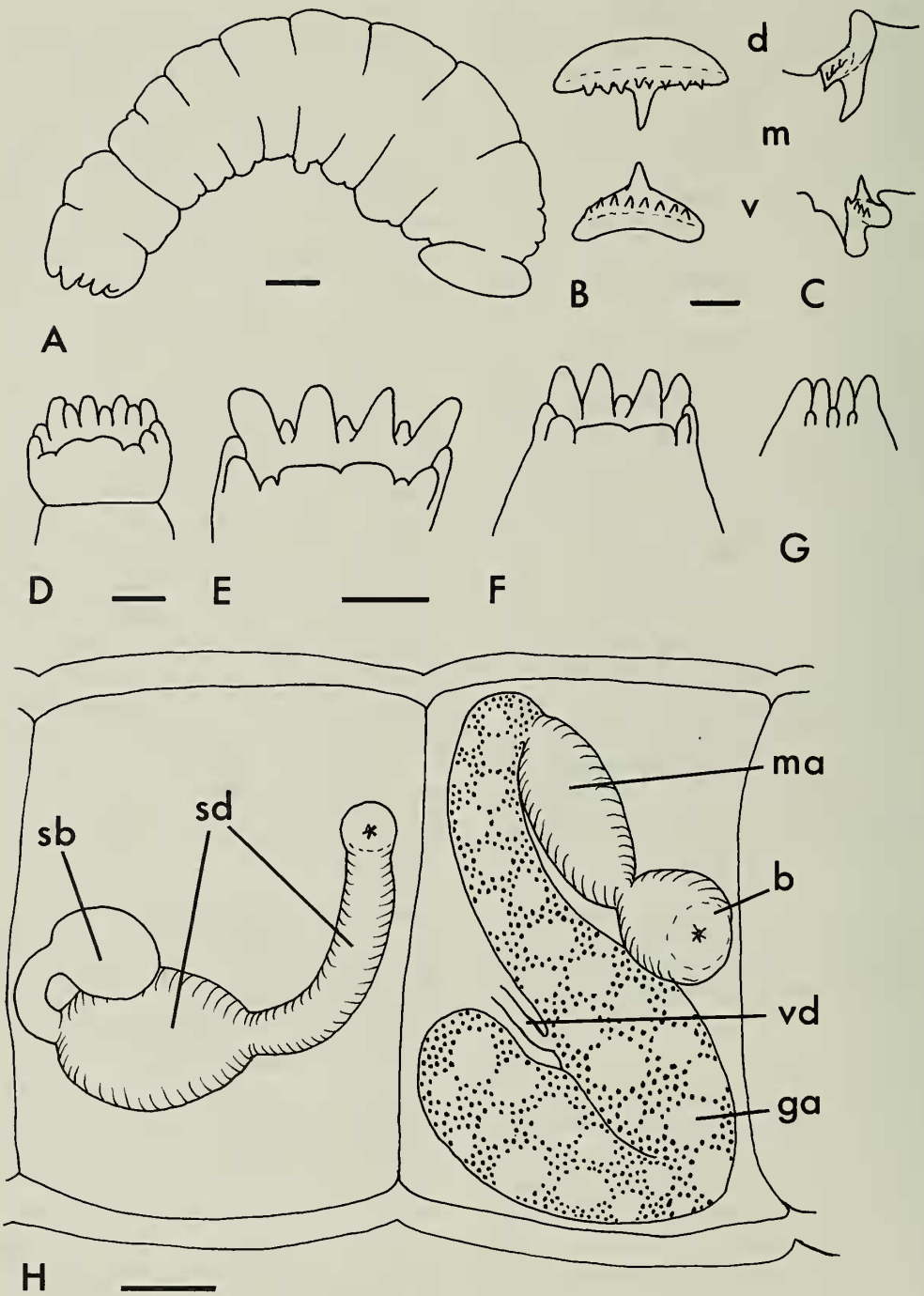

Fig. 2. *Cirrodrilus aomorensis*: A, Lateral view of whole worm, scale bar = 0.1 mm; B, jaws from an anterior aspect; C, jaws from a lateral aspect, scale bar = 10 μm; D, ventral view of the peristomium redrawn from Yamaguchi (1934:196, fig. 6) scale bar approximately 0.1 mm; drawings of the peristomium of a live specimen E, ventral aspect with light pressure, F, ventral aspect with heavy pressure, G, dorsal aspect with heavy pressure, scale bar = 0.1 mm; H, segments 5 and 6 with spermatheca and male genitalia respectively in a living specimen drawn from the ventral aspect, scale bar = 50 μm. Abbreviations: b, bursa; d, dorsal jaw; ga, glandular

specimens. Examination of living specimens enables a better and more consistent view of the appendages to be obtained. Even so, the amount of pressure from the cover-glass on the peristomium can significantly effect the number of appendages that are visible (Fig. 2E–G). Note the apparent disappearance of the ventral lip lobes due to increased pressure in Fig. 2F as compared to those shown in Fig. 2E. The small teeth on both jaws may have additional teeth resulting in a dental formula of 5-1-5/5-1-5; spaces in the regular sequencing suggest the position of missing small teeth.

Distribution.—In 20 towns listed in Table 1, and in the towns of Shichinohe and Mekasawa (Yamaguchi 1934), Aomori Prefecture, northern Honshu, Japan.

Host.—Cambaroides japonicus (de Hann, 1841).

Remarks.—Specimens of *C. aomorensis* were found all over the surface of the body, excluding the gill chambers, and never with any other species of branchiobdellidan. The jaws are shown from both an anterior aspect (Fig. 2B) and a lateral aspect (Fig. 2C). The anterior aspect shows the jaws in the greatest detail and is the most useful in identifying specimens. The dorsal jaw is usually found laying parallel to the lumen so that the median tooth points anteriorly out through the mouth (Fig. 2C, m). The lateral teeth similarly point anteriorly and lie just above the cuticle lining of the mouth. In Fig. 2C, the jaws are drawn with the median teeth in dorsal and ventral jaws facing each other; this is a fixation artifact due to the contraction of muscles in the head. The large median tooth on the dorsal jaw in this species is curved anteriorly, which is an unusual but not unique feature. The large median tooth in most species is directed vertically from the jaw or has a slight posterior curve. In these two latter positions, material ingested into the pharynx would cause the teeth to penetrate the material and hold it in the pharynx. An anterior curve would not act in such a retaining way, but would still puncture the prey while outside of the mouth.

The food and method of feeding has not been reported for specimens of *C. aomorensis*. Observations on the material in the digestive system show that small oligochaetes, diatoms, and small amounts of organic detritus are ingested. Penetration of the body wall or cell wall during ingestion would release soft materials from the organisms' protective covering for digestion in the stomach. In addition, specimens collected by Yamaguchi and more recently during the present study show the stomach in many specimens to be filled with rounded, amorphous material, the origin of which is not known.

Distribution of Branchiobdellidans and their Host Crayfish in Northern Honshu

Details of the sites from which the crayfish, *C. japonicus*, were collected and its branchiobdellidan symbionts is presented in Table 1. The distribution of four *Cirrodrilus* species in northern Honshu, Japan, is presented in Fig. 3. At this time, *C. tsugarensis* has only been reported from its isolated type locality. Although the extensive distribution of *C. aomorensis* across most of Aomori Prefecture (Fig. 3) is not unusual, no explanation for the southern limit of both crayfish and branchiobdellidans can be offered at this time. Interestingly, two isolated populations of *C. aomorensis* on *C. japonicus* were found further south in Akita and Iwate Prefectures. It is possible that crayfish from Aomori Prefecture were introduced into these two locations, or they may be relict populations of a more southern dis-

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atrium; m, mouth; ma, muscular atrium; sb, spermathecal bulb; sd, spermathecal duct; v, ventral jaw; vd, vas deferens.

Table 1.—Distribution of the crayfish, *Cambaroides japonicus,* and its branchiobdellidans in northern Honshu, Japan, based on specimens collected from 1994 to 1999.

Locality	Prefecture	Species	No. of specimens
Unnamed stream in Sunagamori area, Imabetsu Town	Aomori	*C. tsugarensis*	10
Unnamed streams, upper Yunokawa River, Kawauchi Town	Aomori	*C. aomorensis*	25
Unnamed streams, upper Kuchihiro River, Wakinosawa Town	Aomori	*C. aomorensis*	15
Streams entering Lake Usori, Mutsu City	Aomori	*C. aomorensis*	36
Unnamed stream in Kamitaya area, Higashidoori Village	Aomori	*C. aomorensis*	9
Upper Imaizumi River, Higashidoori Village	Aomori	*C. aomorensis*	30
Unnamed stream on Mt. Fukkoshi-eboshi, Yokohama Town	Aomori	*C. aomorensis*	12
Unnamed stream, upper Nonai River, Aomori City	Aomori	*C. aomorensis*	9
Unnamed stream, Shimoyu Reservoir, Arakawa River, Aomori city	Aomori	*C. aomorensis*	18
Unnamed streams, upper Komagome River, Aomori City	Aomori	*C. aomorensis*	7
Unnamed stream on Chobo hill, Aomori City	Aomori	*C. aomorensis*	4
Unnamed stream in Nonaihata area, Hiranai Town	Aomori	*C. aomorensis*	25
Fudo waterfall on Nishinosawa stream, Hiranai Town	Aomori	*C. aomorensis*	6
Nitose Stream, Tenmabayashi Village	Aomori	*C. aomorensis*	20
Unnamed stream in Kuraoka area, Shichinohe Town	Aomori	*C. aomorensis*	15
Hiyamizunosawa Stream in Fujimori area, Shichinohe Town	Aomori	*C. aomorensis*	8
Unnamed stream in Tokusaiji area, Namioka Town	Aomori	*C. aomorensis*	10
Unnamed stream in Oota area, Shiura Village	Aomori	*C. aomorensis*	10
Unnamed stream, upper Kanagi River, Kanagi Town	Aomori	*C. aomorensis*	5
Unnamed streams on Mt. Sakai, Goshogawara City	Aomori	*C. aomorensis*	25+
Upper Tsubokezawa Stream on Mt. Bashin, Goshogawara City	Aomori	*C. aomorensis*	50+
Magenosawa Stream on Oobuchi River, Goshogawara City	Aomori	*C. aomorensis*	50+
Upper courses of Iizume River, Goshogawara City	Aomori	*C. aomorensis*	200+
Unnamed streams in Komozuchi area, Kizukuri Town	Aomori	*C. aomorensis*	10
Unnamed streams in Kamegaoka area, Kizukuri Town	Aomori	*C. aomorensis*	8
Streams entering Pond Tubu-numa, Kizukuri Town	Aomori	*C. aomorensis*	10
Unnamed stream in Maruyama area, Kizukuri Town	Aomori	*C. aomorensis*	30
Unnamed stream in Yonkenya area, Kizukuri Town	Aomori	*C. aomorensis*	20
Komorisawa Stream on Mt. Bonju, Namioka Town	Aomori	*C. aomorensis*	1
Unnamed stream on Mt. Sasamori, Ajigasawa Town	Aomori	*C. aomorensis*	10
Okushirasawa Stream on Mt. Iwaki, Ajigasawa Town	Aomori	*C. aomorensis*	30
Upper Chomae STream on Mt. Iwaki, Iwaki Town	Aomori	*C. aomorensis*	18
Unnamed stream on Mt. Iwaki in Dake area, Iwaki Town	Aomori	*C. aomorensis*	8
Unnamed stream in Ishikawa area, Hirosaki City	Aomori	*C. aomorensis*	38
Unnamed stream in Funada area, Ninohe City	Iwate	*C. aomorensis*	13
Unnamed stream in Mochida area, Oodate City	Akita	*C. aomorensis*	3
Unnamed stream in Osarizawa area, Kazuno City	Akita	*C. inukaii*	20+
		C. uchidai	6

Crayfishes collected by: Doctors A. Ohtaka and S. R. Gelder, and Messers M. Mukohyama, T. Naraoka, M. Oikawa, S. Yamauchi, R. Mayama, A. Abe, M. Sasaki, and Y. Onishi.

tribution. In 1943, *C. japonicus* was introduced into a small stream in Kazuno City, Akita Prefecture (Table 1), from Sapporo, Hokkaido; they were observed to carry *Cirrodrilus inukaii* and *C. uchidai* in 1978 by Mr. T. Komoriya (Japanese Regional report 1978, unpub. obs.). Specimens of the two species were collected by the authors in May 1999 from the same site in Kazuno City.

Discussion

All of the endemic species of branchiobdellidans reported in Japan are members of the genus *Cirrodrilus* and are found on the endemic crayfish, *C. japonicus.* Although

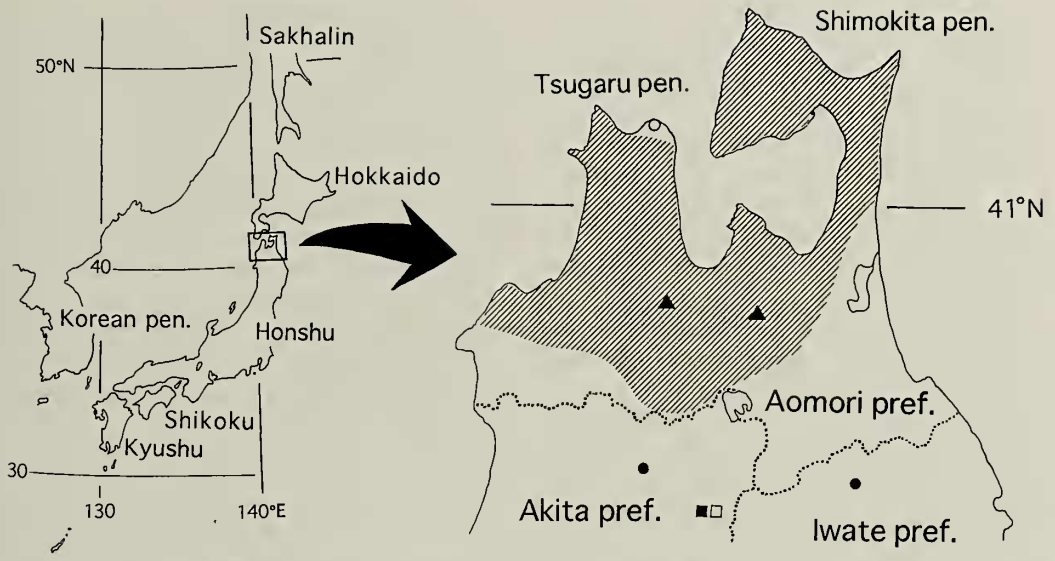

Fig. 3. Map of Japan and adjacent mainland Asia showing the location of Aomori Prefecture in oblong (left). Distribution of branchiobdellidans in northern Honshu, Japan, (right) based on information in Table 1 and other available data: *C. tsugarensis*, open circle; *C. aomorensis*, shaded area (general distribution), solid circles (isolated populations), and solid triangles (original sites from Yamaguchi 1934); *C. uchidai*, solid square; *C. inukaii*, open square.

evidence has been found of *C. japonicus* carrying *Cirrodrilus inukaii* and *C. uchidai* being introduced into Honshu from Hokkaido, no evidence has been found of exotic "mainland" species of crayfish or branchiobdellidans being introduced into Japan. The present work has set the base-line in northern Honshu for observing future developments of the native species as well as the rapid detection of exotic species should they be introduced.

The majority of "mainland" branchiobdellidan species have crayfishes as their hosts, but freshwater shrimps have been adopted successfully as alternative hosts in the following cases: *Caridinophila unidens* Liang, 1963 was found on *Caridina yunnanensis* Yu Shouchie, 1938 in Lake Er-Hai, Yunnan Province, and *Holtodrilus truncatus* (Liang, 1963) on *Neocaridina denticulata sinensis* (Kemp, 1918) from a spring near Sichwan, Hunan Province, and subsequently in the Chanjiang River near Shaoguan, Guangdong Province, China (Liu 1984). The freshwater shrimps, *Neocaridina denticulata* (de Haan, 1849), *Paratya compressa* (de Haan, 1849), and *Palaemon paucidens* de Haan, 1849 have been reported in Japan (Dr. M. Nishino, pers. comm.). Although the distribution of each shrimp species has varying degrees of overlap with *C. japonicus* no branchiobdellidans have been observed on these potential hosts. Therefore, investigators in Japan have a unique opportunity to study the reactions and preferences of branchiodellidans with respect to potential crustacean hosts other than crayfish. The fact that *N. denticulata* and *P. compressa* are already known to carry the platyhelminth temnocephalid, *Scutariella japonicus* (Matjasic, 1990), which has a very similar ectosymbiotic life style to a branchiobdellidan, makes the project even more intriguing (Gelder 1999).

Although Japan has only one native, crayfish species, crayfishes from North America have been imported into the country for stocking bodies of water since 1926. The history of the introductions of Louisi-

ana red swamp crayfish, *Procambarus* (*Scapulicambarus*) *clarkii* (Girard, 1852) and North American signal crayfish, *Pacifastacus leniusculus* (Dana, 1852) into Japan have been reviewed by Kamita (1970). The warm-water species, *P.* (*S.*) *clarkii*, is now commonly found from northern Honshu southwards through Japan. Two subspecies of the cold-water signal crayfish, *Pacifastacus leniusculus leniusculus* (Dana, 1852) and *Pacifastacus leniusculus trowbridgii* (Stimpson, 1857) have successfully colonized a mountain reservoir in Shiga Prefecture and another site in Ishikawa Prefecture, both in central Honshu, and in Lake Mashu, eastern Hokkaido, Japan, (Miyake 1973). A new species of branchiobdellidan, *Cambarincola okadai* Yamaguchi, 1933, was described from specimens removed "in 1928" from "crayfish formerly transferred from America into Lake Chuzenji, Nikko" Yamaguchi (1933:191). This species of branchiobdellidan has not been reported in Japan since the original study and further investigations are needed on this exotic symbiosis.

This survey on the distribution of branchiobdellidans and crayfish in northern Honshu has revealed a more accurate picture than was previously available from the two locations of *C. aomorensis* (Fig. 3) reported by Yamaguchi (1934:196). Given the endemism and extremely limited distribution of *C. tsugarensis*, it is easy to see why the species escaped collection previously. It also indicates that other undescribed species may be present in this region. Further studies on the native and exotic species of crayfishes in Japan and their branchiobdellidans are in progress by the authors. These studies are necessary if a clear understanding of the dynamic associations between the native and introduced crayfish and their symbionts is to be obtained.

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Literature Cited

Gelder, S. R. 1987. Observations on three species of branchiobdellid (Annelida: Clitellata) worms from eastern Asia.—Hydrobiologia 155:15–25.

———. 1996a. A review of the taxonomic nomenclature and a checklist of the species of the Branchiobdellae (Annelida: Clitellata).—Proceedings of the Biological Society of Washington 109:653–663.

———. 1996b. Description of a new branchiobdellidan species, with observations on three other species, and a key to the genus *Pterodrilus* (Annelida: Clitellata).—Proceedings of the Biological Society of Washington 109:256–263.

———. 1999. Zoogeography of branchiobdellidans (Annelida) and temnocephalans (Platyhelminthes) ectosymbiotic on freshwater crustaceans, and their reactions to one another in vitro.—Hydrobiologia 406:21–31.

Grygier, M. J. 1993. Japanese zoological nomenclature.—American Association for Zoological Nomenclature Newsletter, September 1993, p. 5–8.

Holt, P. C. 1967. Status of the genera *Branchiobdella* and *Stephanodrilus* in North America with description of a new genus (Clitellata: Branchiobdellida).—Proceedings of the United States National Museum 124:1–10.

———, & B. D. Opell. 1993. A checklist of and illustrated key to the genera and species of the Central and North American Cambarincolidae (Clitellata: Branchiobdellida).—Proceedings of the Biological Society of Washington 106:251–295.

Humason, G. L. 1979. Animal tissue techniques, 4th edition. W.H. Freeman and Co., San Francisco, 661 pp.

Kamita, T. 1970. Studies on the fresh-water shirimps,

prawns and crayfishes of Japan. Enlarged and revised edition. Sonoyama-Shoten Publishing. Matsue, (in Japanese), 213 pp.

Liu, S.-C. 1984. Descriptions of two new species of the genus *Stephanodrilus* from Northeast China and notes on *St. trunctus* Liang from Guagdong Province (Oligochaeta: Branchiobdellidae).—Acta zootaxonomica sinica 9:351–355.

Miyake, S. 1973. Reptantia. Pp. 496–501 *in* M. Ueno, ed., Freshwater biology of Japan. Enlarged and revised edition, Hokuryukan Publishing Co. Ltd., Tokyo, (in Japanese), 760 pp.

Pierantoni, U. 1906. Nuovi Discodrilidi del Giappone e della California.—Annuario del Museo Zoologico della R. Università di Napoli (new series) 2:1–9.

———. 1912. Monografia dei Discodrilidae.—Annuario del Museo Zoologico della R. Università di Napoli (new series) 3:1–27.

Timm, T. 1991. Branchiobdellida (Oligochaeta) from the farthest South-East of the U.S.S.R.—Zoologica Scripta 20:321–331.

Yamaguchi, H. 1932a. Description of a new branchiobdellid *Carcinodrilus nipponicus* n.g. et n.sp.—Journal of the Faculty of Science, Hokkaido University, Series VI, Zoology 2:62–67.

———. 1932b. A new species of *Cambarincola*, with remarks on spermatic vesicles of some branchiobddellid worms.—Proceedings of the Imperial Academy (Japan) 8:454–456.

———. 1932c. On the genus *Cirrodrilus* Pierantoni, 1905, with a description of a new branchiobdellid from Japan.—Annotationes Zoologicae Japonenses 13:361–367.

———. 1933. Description of a new branchiobdellid, *Cambarincola okadai* n. sp., parasitic on American crayfish transferred into a Japanese lake.—Proceedings of the Imperial Academy (Japan) 9:191–193.

———. 1934. Studies on Japanese Branchiobdellidae with some revisions on the classification.—Journal of the Faculty of Science, Hokkaido University, Series VI, Zoology 3:177–219.